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Abstract:
In this paper the relation between the attractivity of cities as a location for firms and the accessibility via the road network is analyzed. First a brief theoretical introduction on the relation between transport infrastructure and spatial patterns of economic activities is given. In the remainder of this paper the relation between the attractivity of cities as industrial sites, the image of cities and the accessibility of these cities via the road network is analyzed in an empirical study for the Netherlands.
The correlation and the regression analysis both indicate a strong coherence between the valuation of cities as location sites for companies and the relative position of those cities in the Dutch road network

1 Introduction

One of the main assumptions in location theory and modelling is that decisions of actors are based on perfect information. This information serves as an input to the actor's objective function to be maximized. However, in reality information on locational alternatives will be far from perfect; decisions are based on partial information only. Moreover, actors might show satisficing in stead of maximizing behaviour. Such behaviour has impacts on the actual location decisions of firms, since entrepreneurs are not informed about the pro's and cons of all location sites which are of interest as a location for his/hers firm. Empirical research on the spatial knowledge c.q. perception of entrepreneurs is limited (Pellenbarg 1982). The impact of transport infrastructure on the attractivity of a location as an industrial site is important both from a scientific and a policy view. When it is shown that transport infrastructure is one of the critical success factors for the image/reputation of a region, it becomes interesting to improve the image of certain regions by the construction of transport infrastructure. Of course, the impact of the construction of transport infrastructure on the image of the region will depend on the already existing infrastructure networks and the type of infrastructure that will be constructed. A related issue is to which extent the impact of the construction of transport infrastructure on the spatial pattern of economic activities is influenced by the prevailing image of actors concerning the region in which the infrastructure is constructed.

In this paper the relation between the attractivity of cities as a location for firms and the accessibility via the road network is analyzed. In section 2 we will give a brief theoretical introduction on the relation between transport infrastructure and spatial patterns of economic activities. In the remainder of this chapter the relation between the attractivity of cities as industrial sites, the image of cities and the accessibility of these cities is analyzed in an empirical study for the Netherlands. In section 3 the valuation of the attractivity of 67 cities by entrepreneurs is given. In section 4 the accessibility of those cities via the Dutch road network is measured. In section 5 correlations between these measures are studied. Regression analysis is used to explain the valuation of cities by a number of factors of which the accessibility via the road network is one of the explanatory variables. This chapter ends with some concluding remarks in section 6.

2 Attractivity of cities as a location for firms.

The attractivity of cities as a location of firms is closely related to productivity. Economic theory suggests a number of reasons for productivity differences among cities, such as differences in (see Figure 1):

- the quality of the labour force
- sectoral composition
- economies of agglomeration
- the quality of local and non local public infrastructure.

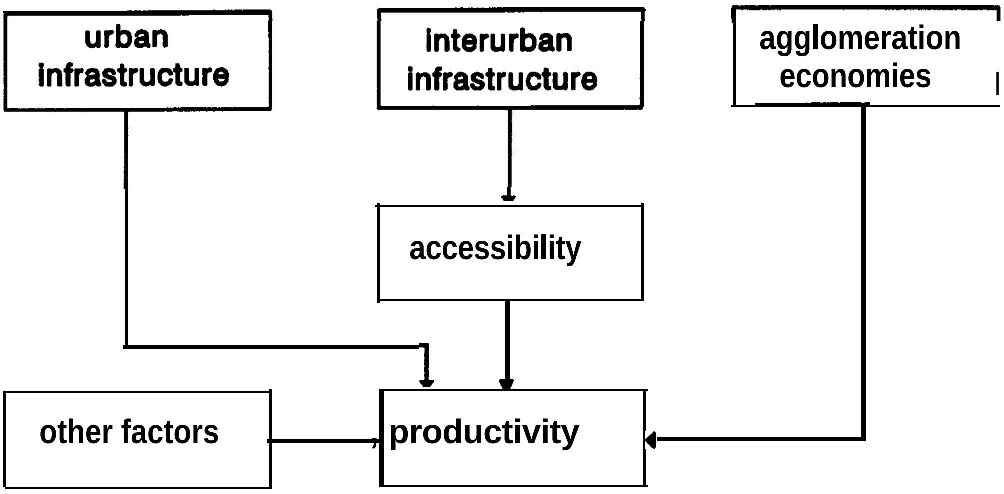

Figure 1 Factors influencing urban productivity

In the present paper we will focus on the last factor, but a closer look will reveal that it is related to the agglomeration factor. During the last decade in economic research much attention has been paid to the contribution of public infrastructure to productivity at various spatial levels. This has led to a wide range of production function based studies leading to rather mixed results. A tendency can be observed that the original high contributions of public infrastructure to investments at the national level such as found by Aschauer (1989) are now supplemented with lower estimates based on dynamic analysis at lower spatial levels (Kelejian and Robinson, 1996). See also Gramlich (1994) and Sturm and de Haan (1995).

An important feature of most studies is that infrastructure is dealt with in an aggregate way (various types of transport modes plus telecommunications, plus public utilities). Spatial spill-overs are ususally ignored. The quality of public infra-structure is typically measured as the size of the public capital stock.
A way to overcome some of these limitations would be to introduce accessibility as an indicator of the services offered by non-local infrastructure. Accessibility can be measured in many ways (cf Bruinsma and Rietveld, 1996 for a review); a common element is that the accessibility of a city is a measure of the potential interactions with other cities. Factors playing a role here are the size of other cities and the transport costs to get there. For particular firms more specific definitions are needed to define accessibility with respect to potential customers or suppliers of inputs.
In order to deal with accessibility, network features of infrastructure have to be taken into account. This obviously leads to a demand for detailed network data, but with current GIS software this is no longer a major bottleneck.

An important issue in the measurement of accessibility of cities is the delimitation of the relevant set of potential destinations. Especially given the relatively high rate of growth of international trade between EU members it is advisable not to ignore destinations abroad. The importance of foreign destionations for city systems depends of course on the particular purpose of the study. In our analysis for the Netherlands we will compare two approaches, one where the city system is confined to Dutch cities only, and one where also larger cities in neighbour countries are included.

A particular feature of the accessibillity notion is that when measuring a cities' accessibility, also the accessibility of the city with respect to itself has to be added. As will be explained and illustrated in the next section, neglect of the internal accessibility term would have counterintuitive results.

The inclusion of the internal component of accessibility has an important implication for the study of another productivity enhancing factor mentioned in the list above: agglomeration economies. Agglomeration economies consist of localization economies which accrue to firms of the same sector because of being close to each other, and urbanization economies which accrue to firms when they are located in urban areas. In a recent article Ciccone and Hall (1996) find that agglomeration economies as represented by density of employment are significant. Their result is that in the US, a doubling of employment density would imply an increase of average labour productivity by around 6 percent. A background of this agglomeration effect is that in high density areas average distances are low so that transport costs are lower as well (note that when cities would be seriously plagued by congestion the agglomaration advantage could become a disadvantage). In addition, levels of specialization in high density areas are higher, leading to higher quality of intermediate inputs and services. Essentially both explanations of the agglomeration effect are based on costs of transport and communication. Hence, the internal component of the accessibility measure is closely related to agglomeration economies. There is a considerable overlap between the two, which has not yet been noted in the literature as far as we know. In the empirical part of this contribution this overlap will receive further attention.

3 The valuation of Dutch cities as industrial sites

Meester and Pellenbarg (1986) investigated the subjective valuation of cities as location sites by entrepreneurs in the Netherlands. Their research was focused on the spatial cognition of entrepreneurs. Cognition is defined as the knowledge of spatial structure, entities and relations. The knowledge does not have to be complete or correct to be considered as cognition (cf. Hart & More 1973). Spatial cognition is often confused with perception. However, perception is limited to the subjective interpretation of the objective reality as directly experienced by the individual, whereas cognition also involves processes like thinking, representation, arguing, judging and remembering. This 'total knowledge' is called cognition in psychology. Especially the visualisation of cognition in mental maps has attracted the attention of geographers. A mental map is defined as the representation of the spatial structure of a city or region in the human brain (Dietvorst et al. 1984). More complex is the term 'image' in which not only spatial characteristics of geographical entities are considered but also non-spatial characteristics (social, political, economic).

Figure 2: The Dutch provinces

In 1983 Pellenberg and Meester have distributed 1800 questionnaires among firms with at least 10 employees and with a national orientation. In the questionnaire a map of the Netherlands was enclosed on which 67 cities were marked. The question was 'Suppose you have to relocate your *firm - whatever the reason might be - how do you value the cities on the map as new location for your firm?'.* The entrepreneurs had to give their values on a five point scale (++, +, 0, -, --). The cities chosen are well known and as far as possible evenly spread over the country. From the 642 returned questionnaires 388 were retained after a correction for completeness of the answers and the number of employees and the spatial orientation of the firm (only firms with more than 10 employees and with a national orientation are included). An index is constructed in which the city which received the highest mean score (Utrecht, in the centre of the Netherlands) got the value 100, and the city with lowest mean score (Winschoten, in the province

Groningen) the value 0 (Appendix A, column 1)[1].
The general picture is that the cities in the province Utrecht score best, followed by the cities of the Randstad and the corridor Breda-Den Bosch-Eindhoven in Noord-Brabant near the Belgian border (see Figure 2 for the location of the provinces). The Randstad area is defined as the area between the cities Utrecht-Amsterdam-Haarlem-Den Haag-Rotterdam-Gouda-Utrecht. However, more interesting is the sharp decline in scores in the provinces Zeeland and Limburg in the south, the upper part of Noord-Holland and the four northern provinces Groningen, Friesland, Drenthe and Overijssel. Those sharp declines show a rather sudden decrease in the valuation of cities as interesting location sites (Meester and Pellenbarg 1986). In their analysis of the mental maps of the entrepreneurs of each province Meester and Pellenbarg arrive at two interesting conclusions. First, there appears to be a kind of neighbourhood effect, meaning a preference for cities within the own province. Second, entrepreneurs located in rather peripheral cities give higher valuations to other peripherally located cities than their collegues in centrally located cities.
The scores of the cities express the mean valuation of the cities. The variance in the valuation of cities by entrepreneurs may of course be substantial. To analyse the basic dimensions underlying the valuations by the entrepreneurs, Meester and Pellenbarg (1986) used a principal component analysis with varimax rotation. Factor analysis replaces a large number of - linked - variables by a limited number of constructed variables, which are by definition independent of each other. By varimax the factors are rotated in such a manner that only heavy loads remain. So each factor is linked to a limited number of variables. This factor analysis results in three components. The first - explaining 25 % of the variance - is interpreted by Meester and Pellenbarg as an accessibility component, in the sense of access to markets (see Appendix A, column 2). The second and third component - explaining 22 and 13 % of the variance respectively - are interpreted as quality of life and agglomeration advantage. The interpretation of the first - accessibility - component is of great interest in this context. If this interpretation is correct the loads of this factor should correlate stronger with the scores of the accessibility via the road network than with the scores of the valuation of cities as location site. This will be tested in section 5.

The exercise is repeated in 1989. In total 152 entrepreneurs out of the 388 entrepreneurs of the first project jointed this second exercise (see Pellenbarg et al. 1993). To compare the first and the second exercise the results of the first project were remeasured only for the subset of entrepreneurs also involved in the second exercise. This has led to some minor changes in the score of some cities (see Appendix A, column 3). Next the scores for 1989 are remeasured to the scale of 1983. Using the same scale a direct comparison between the results of 1983 and 1989 is allowed.

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1 A more accurate analysis could have been carried out by means of an ordered logit model based on individual observations. However, since the original data are no longer available at the micro level the analysis has been carried out at an aggregate level, i.e., the average score of cities accross all respondents on a scale from 0 to 100.

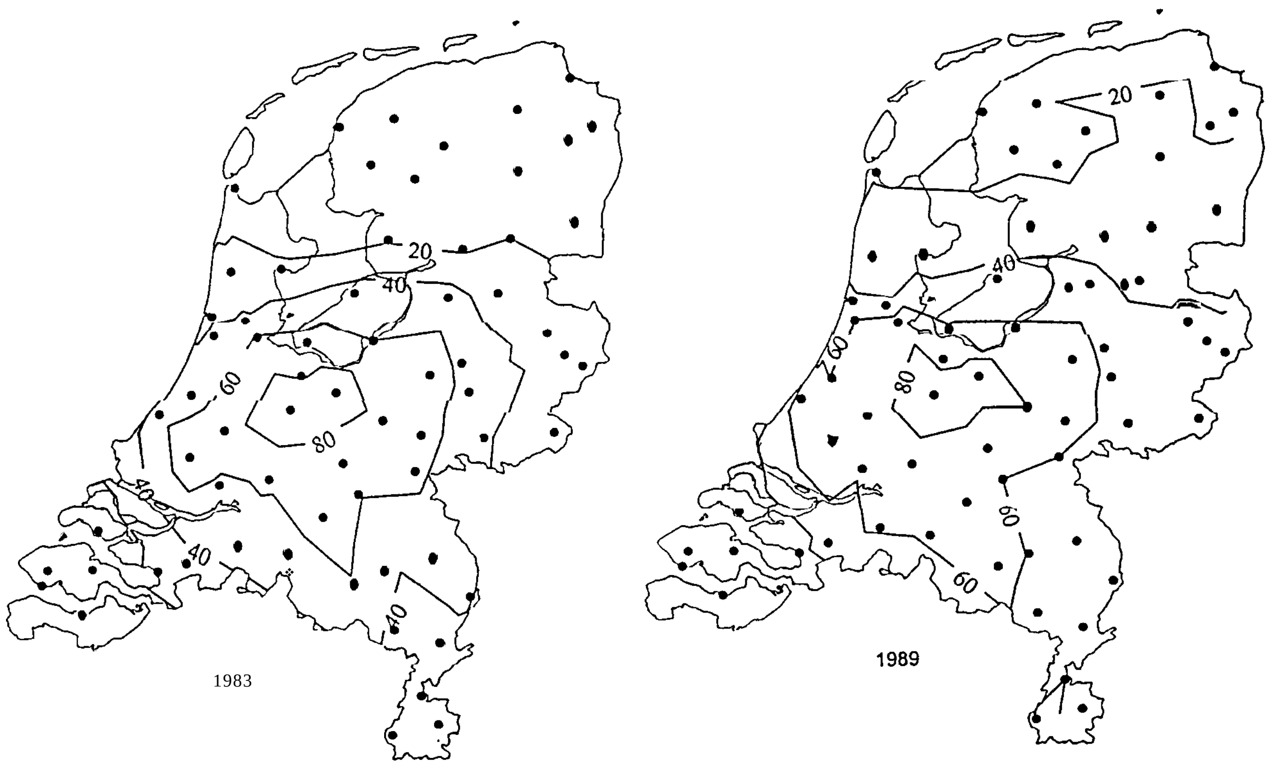

Figure 3: Valuation of cities as location sites of firms (1983 and 1989)

The results are shown in Figure 3. Compared to 1983 the peak in 1989 is lower which might be explained by the increasing congestion in the most prefered area. Not only the peak is lower but also the isolines tend to move outwards. This is an indication of a general rise in the valuation of cities as location sites by entrepreneurs. In the period 1983-1989 the average score per city increased by nearly 9 percent.

The studies described above give the opportunity to analyze the relation between transport infrastructure and the subjective location preferences of entrepreneurs in the Netherlands for the period 1983-1989. In the next section the accessibility via the road network is operationalized and accessibility indices are constructed.

4 Accessibility of the cities via the road network

4.1 Operationalization accessibility

Accessibility concerns the geographical location of the city considering all other cities. If the mean distance to all other cities is relatively short, then the location of the city within the network is relatively favourable. A relatively well located city within the city network has a better potential to attract national or international oriented firms compared with an unfavourably located city within the network. For a review of accessibility concepts we refer to Bruinsma and Rietveld (1996). In the present paper we use the following approach. Our conceptualization of accessibility considers the travel times or distances between cities via the road network. The following simple gravity approach is used:

$$B_i = \Sigma_j \, 1/R_{ij} \qquad (1)$$

The accessibility (B_i) of a city is measured as the summation (in the sense of a harmonic mean) of all travel times to all relevant destinations (R_{ij}). The gravity parameter c in general receives the value 1 (see Keeble et al. 1982 and Cheshire 1990). Since the interaction between cities increases when the population size of the cities increases, it is reasonable to introduce weighing by the population size of the cities. This leads to the following equation in which P_j stands for the population size of the destination j;

$$B_i = \Sigma_j \, P_j/R_{ij}^c \qquad (2)$$

The fact that the interaction within the city i is ignored would imply that relatively large cities score relatively low. This can be corrected by including the internal interaction potential into the gravity model. The internal interaction potential is depending of the size of the own city (P_i) and the mean internal travel time (r_i). The gravity model can now be described in the following form:

$$B_i = P_i/r_i^c + \Sigma_{j \neq i} \, P_j/R_{ij} \qquad (3)$$

The internal travel time depends on the surface of the city (0) and the average travel speed (s). Conform Rich (1980) the average internal distance (d) can be measured as follows:

$$d = \sqrt{(O/\pi)}/2 \qquad (4)$$

After measuring the internal distance, the mean internal travel time (r_i) can be calculated on basis of the average internal travel speed. As we will show in our empirical application, the outcomes for the accessibility index depend considerably on the way the internal accessibility is modelled. This is a topic that has not received much attention in the literature. Therefore we deal with this issue in our application.

4.2 The accessibility measures

The accessibility of the 67 Dutch cities via the road network is measured for the years 1983 and 1989. Conform the approach of Meester and Pellenbarg (1986), the results were scaled from 100 for the most accessible city to 0 for the least accessible city.

4.2.1 Centrality indices

In a first series of calculations only the distance via the road was included (equation 1). The results are shown in Appendix B (column 1) and Figure 4. Since the index is completely dependent on the distances via the road network, we will call this index the centrality index. If we compare this index with the index

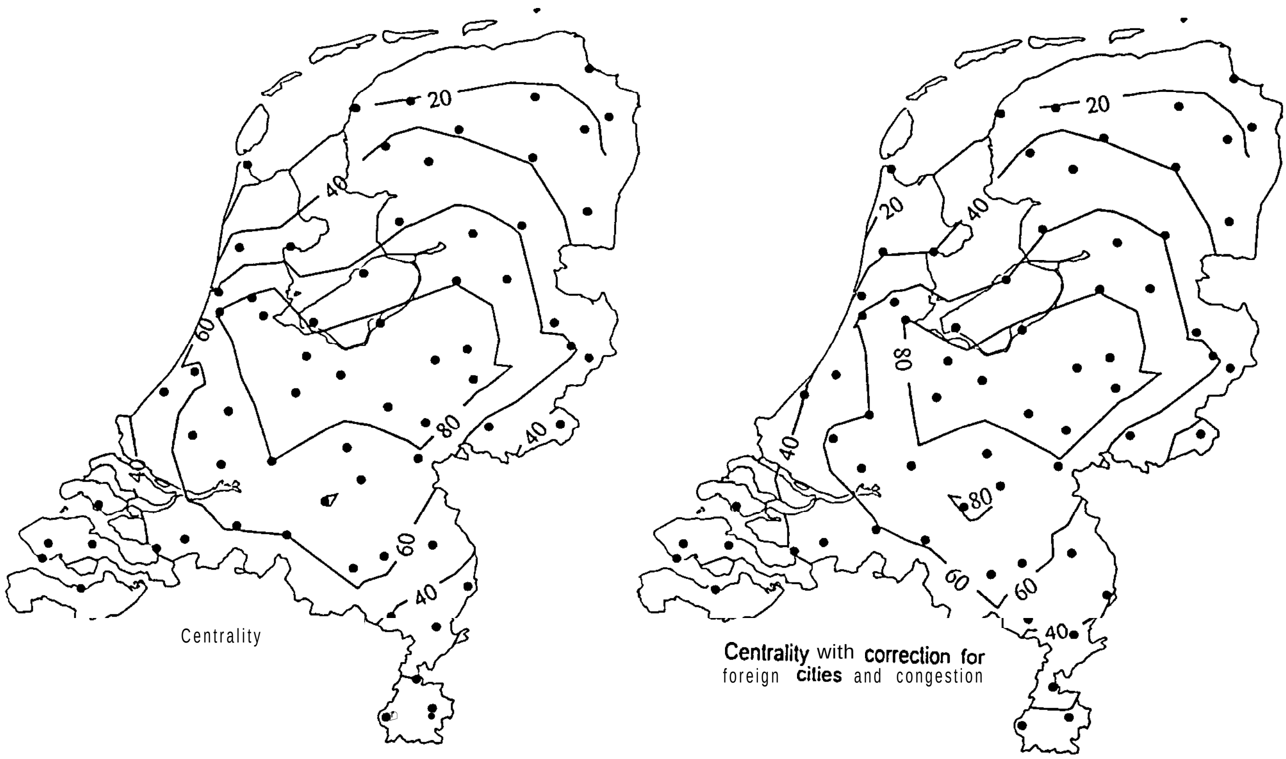

Figure 4: Centrality of cities via the Dutch road network

in which the entrepreneurs value the cites as location sites, a few differences appear. Amsterdam is the best scoring city in terms of centrality in stead of Utrecht. Moreover, the peak of the centrality index is flatter; the 80 and 60 isolines cover a much larger area. An objection against this centrality index might be that international relations are left out. This might be a disadvantage for cities in border regions. To analyze the impact we added all foreign cities within 100 kilometres via the road network from the border and with a population size at least comparable to the Dutch cities. The cities added were Antwerp, Brussels, Liege and Gent in Belgium and Aken, Köln, Bonn, Duisburg, Dusseldorf, Dortmund, Wuppertal, Osnabrück, Munster and Essen in Germany. Conform Bruinsma and Rietveld (1994) the interactions with foreign countries are reduced by .333 to indicate the barrier of an international border. The impact of the foreign cities on the scores of the Dutch cities is rather small and limited to cities in Limburg and to a less extent Noord-Brabant (see Appendix B, column 2). No impacts are measured for the northern cities close to the border. This is caused by the fact that there are no large German cities within 100 kilometre of the border in the northern part of the Netherlands.

In the period 1983-1989 the extensions in the Dutch main road network are limited to some quality improvements or upgradings of existing roads. The centrality index for this period remained the same.
As mentioned in section 3 Pellenbarg et al. (1993) concluded that the flattening of the peak in the central part of the Netherlands in the period 1983-1989 might be explained by an increasing congestion in this area. We added congestion to the

model by increasing the travel time according to the share of each link between the cities that was located inside the Randstad area. When the percentage of the link between two cities inside the Randstad is 10 to 24 %, we increased the travel time by 5 %. Is the percentage 25-49, 50-74 or over 75 % then we increased the travel time by 10, 15 and 20 % respectively. Outside the Randstad area are still two roads (near Breda and Vianen) which were in the top 20 of the most congested roads in 1989. Links using these roads also received a penalty of 5 %. The results of this adding of congestion is twofold. The scores of cities inside or close to the Randstad area decrease; the relative accessibility of cities in Limburg slightly increases (see Appendix B, column 3 versus column 1).

A final accessibility index is calculated in which foreign cities and congestion are, added (see Figure 4 and Appendix B, column 4). Compared with the index without those additions the change in scores of the Randstad cities is heavily depending on the congestion, whereas the scores of the cities in Limburg and to a less extent Noord-Brabant are increasing by both corrections. An exception has to be made for Breda in Noord-Brabant. The congested road near that city has a negative impact on its accessibility which is larger than the positive impact of being located close to some Belgian cities.

4.2.2 Accessibility indices

Until now the accessibility of the cities is measured only by distances via the road network. A first extension is given in equation (2) where weighing by the population size takes place (Appendix B, column 5). In this equation the weighing is restricted to the population size of the destinations. The internal interaction within the city itself is neglected. There are two objections against this procedure. The first objection is that it leads to an underestimation of the importance of large cities. When a city has a relatively large share in the total population, the rest population to interact with is relatively small and so the final score will be rather small. This effect is shown by Bruinsma and Rietveld (1993) for the accessibility of Paris and London in the European infrastructure networks. However, in this. case study there is no city with an unevenly large share in total population, so the impact will be limited. The second objection has a larger impact. This objection considers the fact that the accessibility of relatively small cities located near to a large urban area is overestimated. The impact is shown for Zaandam. This city is located near to Amsterdam (11 kilometres, nearly 700,000 inhabitants) and is one of the best accessible cities. The share of Amsterdam in the total score of Zaandam is 46 %. So, the accessibility of Zaandam heavily depends on its nearness to Amsterdam. However, the accessibility of Amsterdam itself is calculated neglecting its own size.

Because of these problems, equation 3 is used to calculate the relative accessibility of cities within the Dutch road network when also the internal interaction potential of cities is taken into account. The mean internal distance has first been calculated by using in equation 4 the surface of the municipalities (Appendix B, column 6). This appeared to be an unlucky choice, since there are large differences in the share of the built up area within municipalities. For example the built up area of Den Haag covers nearly all the surface of the municipality. Using the surface of the municipality to calculate the mean travel distance leads to a share of the internal interaction potential in the total score of 73 % in the case of Den

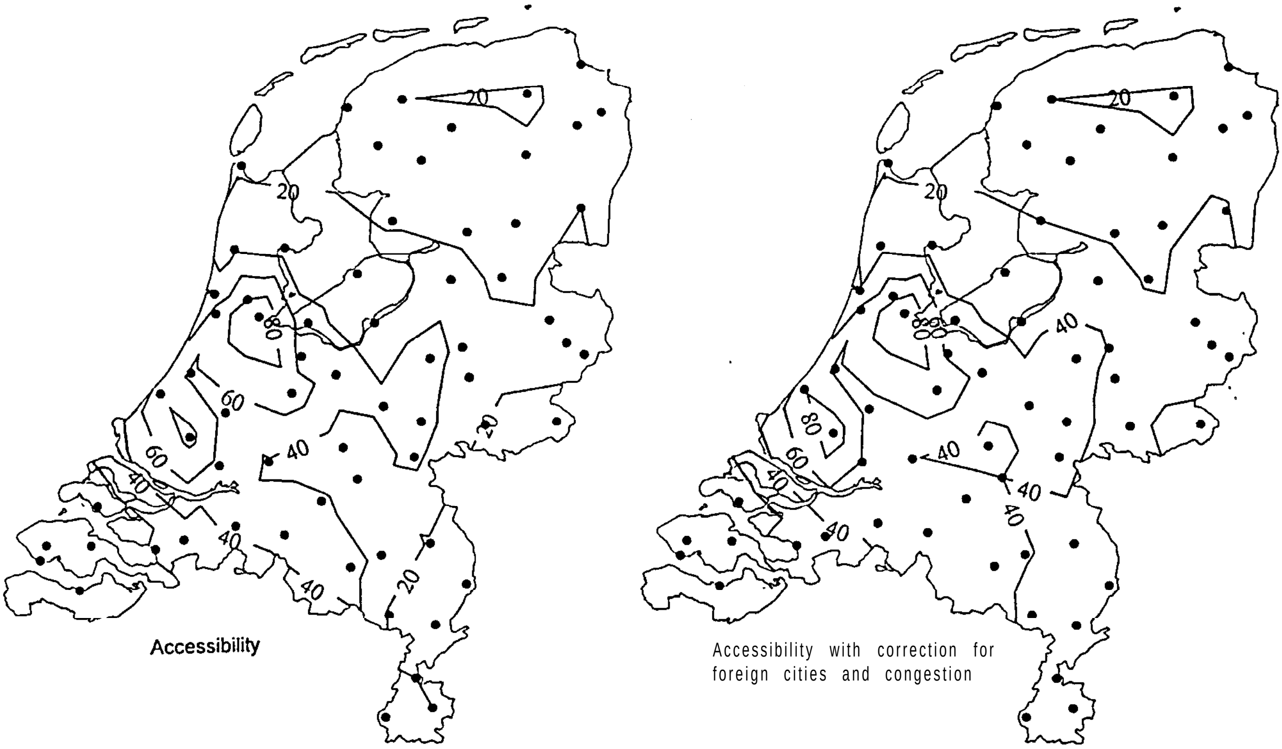

Figure 5: Accessibility of cities via the Dutch road network (1989)

Haag. This makes Den Haag the best accessible city. On the other hand the share of the internal interaction potential in the total score of the municipality of Apeldoorn is only 27 %, and it is ranked on the 26th place. The built up area of this municipality is relatively small compared to its surface.
It is important to note that two factors influence the size of the share of the internal interaction potential; the size of the city and the relative position of the city within the road network. The population size of Den Haag is larger then that of Apeldoorn, what is a justification for the larger share of Den Haag. However, Den Haag is also more closely located to a number of other large cities within the Randstad. Since in spatial interaction models relatively short distances lead to strong interactions, also the external accessibility might be expected to be higher than that of Apeldoorn. This conflicts with the relatively high share of the internal interaction potential for Den Haag. We conclude that the use of the surface of municipalities does not lead to satisfactory results. Conform Bruinsma and Rietveld (1993) the size of the urban area is calculated by assuming an urban population density of 2,000 inhabitants per km^2 (see Appendix B, column 7). Den Haag is now ranked fourth with a share of the internal interaction potential of 59 % and Apeldoorn is ranked fourteenth and the share of the internal interaction potential has increased to 45 %.
The same approach is used to calculate the accessibility of cities for the year 1989 (Figure 5 and Appendix B, column 8). The differences in the indices are not explained by improvements in the road network (see the centrality index), but by different growth rates of cities in the period 1983-1989. The differences in population growth rates influence both the external accessibility and the internal

interaction potential. A growth rate which is higher compared with the growth rate of the best accessible city (Amsterdam) results in an increasing share of the internal interaction potential. An example is Almere. The share of the internal interaction potential of this city is increased from 24 to 31 % over this period. In all other cities much smaller changes occured. Besides an improved accessibility by a relatively fast increase in the city's own population size, a city can improve its accessibility when it is located near to a fast growing city. In this case the share of the external accessibility increases.
A comparison of the centrality index with this weighed accessibility index shows a clear shift of the most accessible centrally located area towards the major cities, especially within the Randstad. The accessibility of the largest population centres (Amsterdam, Rotterdam and Den Haag) is strongly depending on the share of the internal interaction potential (61, 62 and 59 % respectively). The accessibility of the city Groningen also heavily depends on its own population size. The share of this city's internal interaction potential in total accessibility is with 63 % the highest. On average the share of the internal interaction potential is 40 %.
Conform the centrality approach the weighed accessibility index has also been calculated when the foreign cities, congestion and both factors are added to the gravity model (see Appendix B, column 9, 10 and 11).
By adding the foreign cities, the accessibility of the cities of Limburg increases even more as was the case in the centrality index. Those cities are not only located relatively close to a number of German cities, but those German cities have relatively large population sizes. The impact of congestion is less dramatic for the accessibility of the Randstad cities. The adding of the congestion in the Randstad area has no impact on the internal interaction potential of the cities in this area. In the calculation where both factors are added, the impact of foreign cities is most important (see Figure 5). The accessibility of all cities in Limburg is now above the 20 isoline. More important - opposite to the centrality index - in the case of Breda the positive impact of the location near Belgian cities exceeds now the negative impact of a congested road nearby.

5 Road infrastructure and the valuation of location sites

In this section the relation between the accessibility of cities via road infrastructure and their valuation as a location site for firms is investigated by correlation and regression analysis.

5.1 Correlation analysis

In Table 1 the correlations are given between the valuation of cities as location sites for firms and their relative position within the Dutch road network. The correlation coefficient shows the relative strength of the relation between the two factors. In Table 1 the Pearson correlations, based on the cities index value, and the Spearman correlations, based on the ranking of the cities, are given. The correlations found are all rather high. In general, the correlations are slightly higher when rank numbers are considered compared with the quantitative values. The loads on factor 1 of the factor analysis of Meester and Pellenbarg (see

Table I: Correlations between the valuation of cities as location sites and their relative position in the road network

		Valuation *of cities as location site for firms*			
		1983	factor I	1983 (n=152)	1989
Centrality indices					
1983 = 1989	index	.832	.829	.818	.763
	rank	.844	.843	.831	.773
1989 foreign cities included	index				.790
	rank				.794
1989 congestion included	index				*,742*
	rank				.751
1989 both included	index				.766
	rank				.775
Accessibility indices					
1983	index	.807	*,708*	*,746*	
	rank	.868	*,802*	*,835*	
1989	index				.802
	rank				.834
1989 foreign cities included	index				.802
	rank				.856
1989 congestion included	index				.790
	rank				.845
1989 both included	index				.827
	rank				.869

section 3) correlates better with the centrality index than with the accessibility index. This underpins the interpretation that Meester and Pellenbarg (1986) gave: factor 1 reflects the physical accessibility. The impact of the addition of foreign cities and/or congestion into the model only leads to minor changes in the correlation coefficients. In case of the centrality indices, the correlation coefficient after adding foreign cities is slightly higher and after adding congestion slightly lower. When both are added the impact of foreign cities and congestion neutralize each other. This result holds true for the indices based on the ranking of the cities as well as for the indices based on the scores of the cities. Thus, the valuation of cities is not only influenced by their position in the Dutch road network, but also international links receive a certain weight. Congestion does not seem to play a role in the valuation in these years.
The impacts of foreign cities and/or congestion are less unambiguous in case of the accessibility indices. So no real indication is found that internationalisation and congestion changed the valuation of cities as location sites for companies in the period 1983-1989. However, the situation might have changed rather drastically since then. The ongoing growth of congestion, especially in the Randstad area, and the creation of one common European market by the end of 1992 might have had strong impacts on the valuation of cities as location sites for firms in the period after 1989.

The correlation analysis shows that although there are some differences in the correlation coefficients, those differences are rather small. The correlations found

Table 2: Location factors according to entrepreneurs

location	strategic, central location in relation to suppliers and costumers
infrastructure	roads, rail roads, parking lots
accessibility	accessibility not related to 'location' and 'infrastructure'
bond with the region	historical bond, personnel not prepared to relocate
characteristics of building/site	size, quality, representativity
prices real estate	land prices, construction prices, rents
government	subsidies, construction regulations, licenses, civil cervants
labour market	quality and quantity of personnel
agglomeration advantages	service sector
competitive considerations	competitive advantages and disadvantages
mentality population	labour mentality
environmental quality	natural parks, landscape, crime

Source: Meester and Pellenbarg, 1986.

Table 3: Operationalization of location factors

location factor	operationalization
location	.
infrastructure	centrality and accessibility indices
accessibility	▲
bond with the region	
characteristics of building/site	▪
prices real estate	square metre prices of office buildings
government	investment subsidies
labour market	unemployment/vacancy ratio
agglomeration advantages	population size
competitive considerations	•
mentality population	
environmental quality	crime in county court district

appear rather unsensitive for changes in definitions. However, one has to be aware that until now only mono causal relations are investigated. In the next subsection the focus is on a multi variate approach to investigate the valuation of cities as location sites for firms.

5.2 Regression analysis

In the regression analysis the valuation of cities as a location site for firms is explained by a number of variables. The explanatory variables are chosen as close as possible to the factors Meester and Pellenbarg (1986) deduced from open interview sessions with entrepreneurs. In those open sessions entrepreneurs had to mention the most important factors in the search for a new location site for their company. The factors mentioned are given and explained in Table 2. Of all factors mentioned 41 % is about 'location', 'infrastructure' and 'accessibility'. Other factors often mentioned are 'bond with the region' and 'characteristics of the building/site' (both about 10 %).

In Table 3 the translation of those factors in variables of which data is available is given. For the first three factors deduced by Pellenbarg and Meester the centrality and accessibility indices given in section 4 are used. It is hard to find data at the desaggregated level of municipalities for most of the other factors. For the year 1983 only data on population size (as an indication of agglomeration advantages) and investment subsidies is available. Fortunately, for 1989 there is also data available on unemployment and vacancies at the municipality level, so we can calculate the unemployment/vacancy ratio. The average rent price of office buildings - in m^2 prices - at the municipality level is calculated for 46 cities on basis of supply side information given by a real estate journal (VGM 1990). The crime variable is based on county court district data (CBS 1989).

The regression analysis is applied to:

$$Y" = a, + \alpha_1 x_{1n} + \alpha_2 x_{2n} + \alpha_3 x_{3n} + \alpha_4 x_{4n} + \alpha_5 x_{5n} + \alpha_6 x_{6n} \tag{5}$$

where:

y_n = value of city n as location site

x_{1n} = centrality or accessibility of city n

x_{2n} = population size of city n

x_{3n} = unemployment/vacancy ratio of city n

x_{4n} = m^2 price of offices in city n

x_{5n} = percentage investment subsidy in city n

x_{6n} = crime in county court district in which city n is located

For the year 1989 sixteen regression analysis have been carried out. The centrality index and the accessibility index have also been used when foreign cities and/or congestion are added. Since office prices are available for only - the largest - 46 cities, all regression analyses are made with and without this variable. In the analyses in which office prices are included hardly any city of the peripheral areas is included.

The results of the regression analyses are satisfactory. The R-squared varies from .60 to .77. The results of a subset of the regression analyses are given in Table 4. The negative sign of the unemployment/vacancy ratio (significant at the 5 % level in most cases) means a positive impact on the valuation of a city as a location site when there are relatively many vacancies in relation to unemployment. A relatively large number of vacancies is seen as an indicator of a dynamic urban economy in stead of an indication that it is hard to recruit personnel. The Dutch labour market was rather much in a situation of excess supply in 1989. Hence, even with a relatively low unemployment/vacancy ratio in a certain city there is not much danger of recruitment bottlenecks.

In a strict sense one would expect a negative sign for the office space price level: a rational entrepreneur would prefer a low cost location above a high cost one. However, it may well be that the office space price level functions here are a proxy for other unobserved variables. An example of such an unobserved variable might be the strong presence of dynamic firms leading to relatively high office prices. In such a case firms might perceive high office prices as a positive signal. Note that real estate studies often interpret low office prices as a bad indicator of

Table 4: Regression analysis of valuation of cities for various specifications of road infrastructure

	office prices exluded (n=62)		office prices included (n=45)	
Centrality index, without *foreign cities and congestion*	coefficient	standard error	coefficient	standard error
constant	20.65	5.56	11.63	13.38
road infrastructure	0.510	0.069	0.439	0.087
population size'	0.039	0.014	0.018	0.017
unemployment/vacancy ratio	-0.608	0.248	-0.588	0.312
square metre office price	--	--	0.101	0.067
investment subsidy	0.081	0.135	0.176	0.161
crime in county court district'	0.140	0.365	0.084	0.400
R-squared	0.690		0.687	
Centrality index, foreign cities and congestion included	office prices exluded (n=62)		office prices included (n=45)	
	coefficient	standard error	coefficient	standard error
constant	17.62	5.24	9.88	12.63
road infrastructure	0.540	0.064	0.483	0.084
population size'	0.043	0.013	0.025	0.015
unemployment/vacancy ratio	-0.565	0.231	-0.558	0.294
square metre office price	--	--	0.090	0.064
investment subsidy	-0.009	0.123	0.073	0.052
crime in county court district'	0.035	0.330	0.241	0.383
R-squared	*0.734*		0.722	
Accessibility index, without foreign cities and congestion	office prices exluded (n=62)		office prices included (n=45)	
	coefficient	standard error	coefficient	standard error
constant	30.82	5.24	20.52	14.85
road infrastructure	0.968	0.155	0.721	0.208
population size'	-0.049	0.022	-0.041	0.024
unemploymenthacancy ratio	-0.626	0.267	-0.677	0.350
square metre office price	--	--	0.108	0.0767
investment subsidy	0.154	0.148	0.220	0.185
crime in county court district'	0.543	0.440	-0.261	0.532
R-squared	0.642		0.603	

1 = * 1,000

urban economies.
The crime variable is not significant. This means that at this spatial level of analysis criminality does not affect the perception of locations. It is not impossible however, that at a more detailed spatial level criminality would play a role in the perception of entrepreneurs.
For the investment subsidy in the majority of the cases a positive coefficient is found. However, the coefficient is not significant. Thus, our analysis doet not support the hypothesis that investment subsidies make entrepreneurial views on particular locations more favourable.
The empirical results show that also in a multivariate context centrality is a quite significant explanatory factor of entrepreneural valuations of locational sites. This

result is no surprise given the similarity between Figures 4 and 5, and also the high simple correlation coefficients in Table 1.
The specification where congestion and transborder effects are taken into account has a better fit. Hence, in the multivariate context our results indicate that congestion and internationalisation are factors that do matter in the entrepreneur's view.
An interesting property of the upper four results in Table 4 is the positive coefficient for the city size variables. Thus, agglomeration advantages do matter in entrepreneurial valuations (cf section 2). An alternative interpretation might be that larger cities are better known than small cities which might have led to an upward bias in the responses of the entrepreneurs for large cities.
The introduction of the accessibility variable in conjunction with city size leads to an unexpected result: the sign for the city size coefficients is negative. In the upper part of Table 4 where centrality was used as a road infrastructure indicator, a positive urban size effect was found. The background of these diverging results is that the accessibility of a city depends strongly on the city's own urban size (see section 4.2.2). Thus, the accessibility variable combines two notions: internal agglomeration advantages, and external proximity. In the context of a study where one is interested in both agglomeration advantages and external accessibility, it is better to represent these notions by means of separate indicators.

The impact of the location of the city in the road network on the valuation of cities as location sites is considerable. The variable is clearly significant; t-values vary from 3.5 till 9.6. The coefficient of .51 in the case of the centrality index (m^2 office prices excluded) implies that an increase of 1 point on the centrality index translates into a .51 point increase on the index in which cities are valued as attractive location sites. To compare; a growth of the population size of a city by 100,000 inhabitants implies an increase of 3.9 points on this index.

6 Conclusion

In this survey among Dutch entrepreneurs the cities in the province of Utrecht are valued as the best location site. Other cities which score relatively high are the Randstad cities and to a less extent the corridor of cities in Noord-Brabant near the Belgian border. Cities in the northern and southern provinces score poorly. However, in the period 1983-1989 there is a tendency that these differences become smaller.

To measure the centrality of cities a gravity model is used based on the distances via the road network. The model by which the accessibility of cities is measured has two additions; the internal interaction potential and a weighing by the population size of the destinations. In the centrality index cities in the northern part of the Randstad and cities in the central part of the country score relatively high. In the accessibility index the large cities in the Randstad score extremely well. The impact of introducing foreign cities into the analysis has a larger impact on the accessibility index than on the centrality index. The foreign cities which are located within 100 kilometres via the road network from the Dutch border have relatively large numbers of inhabitants. In both types of indices the scores of the cities in Limburg and to a less extent Noord-Brabant improve most by the adding of foreign cities.

Correlation and regression analysis are used to investigate the relation between the valuation of cities as location sites by entrepreneurs and the accessibility/centrality of those cities in the Dutch road network. The correlations found are relatively high and rather unsensitive to changes in definitions. In a multi variate analysis both the centrality and the accessibility indices contributed most to the explanation of the valuation of the cities as location sites for firms.

We also included city size as an indicator of agglomeration economies. Indeed, larger cities are valued as more attractive than smaller cities by entrepreneurs. However, an alternative interpretation would be that larger cities are better known by entrepreneurs than small cities, which may lead to biased responses.
The inclusion of city size as an indicator af agglomeration economies may interfere with the use of accessibility as an indicator of the quality of infrastructure. The reason is that the internal component of accessibility tends to get a relatively high share. Thus, in empirical studies where accessibility is used it does not only represent the quality of the external network of a city but also the internal agglomeration economies. This may give the accessibility indicator a somewhat hybrid character.

The correlation and the regression analysis both indicate a strong coherence between the valuation of cities as location sites for companies and the relative position of those cities in the Dutch road network. Now this coherence is proven a number of interesting questions rise. It is interesting to investigate the relation between the valuation of a city as a location site for firms and the actual (re-)location pattern of firms. When such a relation appears to exist it becomes interesting to focus research on the extent to which the impact of the construction of transport infrastructure on urban economic development is affected by the image of the city as a location site for firms.

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Appendix A: Valuation indices of cities as a location site for firms

Prov.	City	1	2	3	4	Prov.	City	1	2	3	4
Gr	Groningen	14	,716	15	25	NH	Alkmaar	28	,491	28	32
Gr	Delfzijl	3	,833	2	16	NH	Den Helder	12	,720	9	18
Gr	Winschoten	0	,780	1	17	NH	Hoorn	25	.514	22	29
Gr	Veendam	1	,788	3	18	NH	Hilversum	79	-.165	78	72
Fr	Leeuwarden	9	.769	8	19	ZH	Den Haag	61	.181	55	68
Fr	Harlingen	6	.813	0	16	ZH	Leiden	57	.119	52	59
Fr	Sneek	6	,777	1	14	ZH	Gouda	73	-.045	71	69
Fr	Heerenveen	9	,747	4	16	ZH	Gorinchem	69	.043	62	69
Fr	Drachten	8	.771	5	17	ZH	Dordrecht	65	.194	57	63.
Dr	Assen	16	.681	12	24	ZH	Rotterdam	82	,171	73	82
Dr	Emmen	14	.691	13	27	Ze	Middelburg	8	.751	6	22
Dr	Hoogeveen	20	.620	20	30	Ze	Vlissingen	11	.748	7	24
Dr	Meppel	22	.554	19	31	Ze	Terneuzen	5	,764	5	22
Ov	Zwolle	47	,364	48	46	Ze	Goes	8	,753	5	24
Ov	Ommen	27	,423	30	34	Ze	Zierikzee	8	.752	5	22
Ov	Almelo	28	,487	30	43	NB	Den Bosch	64	,099	69	74
Ov	Hengelo	30	.503	32	47	NB	oss	52	,091	61	60
Ov	Enschede	28	.512	30	45	NB	Helmond	43	,294	51	59
Ov	Deventer	49	.248	54	54	NB	Eindhoven	54	,294	59	69
Ge	Arnhem	68	.003	69	72	NB	Tilburg	51	.255	52	63
Ge	Ede	71	-.148	73	80	NB	Breda	53	.283	54	67
Ge	Harderwijk	57	.092	60	62	NB	Roosendaal	35	.462	34	44
Ge	Apeldoorn	66	.013	75	74	NB	Bergen op Zoom	26	.535	5	38
Ge	Zutphen	43	,245	51	54	Li	Maastricht	20	.585	25	39
Ge	Winterswijk	23	.500	27	40	Li	Heerlen	18	.580	25	41
Ge	Doetinchem	37	,260	42	48	Li	Sittard/Geleen	18	.584	23	40
Ge	Nijmegen	60	,119	66	60	Li	Roermond	27	.514	37	46
Ge	Tiel	65	-.105	67	68	Li	Weert	28	,485	35	48
Ut	Utrecht	100	-.244	100	98	Li	Venray	35	.342	43	49
Ut	Amersfoort	90	-.246	94	89	Li	Venlo	34	,436	42	53
NH	Amsterdam	68	.148	61	69	Fl	Almere	72	,023	67	62
NH	Haarlem	57	.223	50	60	Fl	Lelystad	54	.266	48	46
NH	IJmuiden/Velsen	38	.463	34	42	Fl	Emmeloord	22	.518	18	33
NH	Zaandam	47	,318	43	42						

Provinces

Gr = Groningen
Fr = Friesland
Dr = Drente
Ov = Overijssel
Ge = Gelderland
Ut = Utrecht
NH = Noord Holland
ZH = Zuid Holland
Ze = Zeeland
NB = Noord Brabant
Li = Limburg
Fl = Flevoland

1 = 1983 (n=388) 2 = loads on first factor 3 = 1983 (n=152) 4 = 1989

Appendix B: Centrality and accessibility indices

Prov.	City	1	2	3	4	5	6	7	8	9	10	11
Gr	Groningen	28	27	30	29	1	24	27	27	27	29	29
Gr	Delfzijl	9	8	11	10	0	1	1	1	1	1	1
Gr	Winschoten	15	14	17	16	1	2	0	0	0	0	0
Gr	Veendam	27	26	29	28	4	1	5	5	5	5	6
Fr	Leeuwarden	34	33	35	35	6	14	18	19	19	20	20
Fr	Harlingen	21	21	23	22	9	6	3	4	4	4	4
Fr	Sneek	42	42	44	43	13	11	10	10	11	11	11
Fr	Heerenveen	48	48	50	49	13	5	12	13	14	14	14
Fr	Drachten	38	38	40	39	11	2	9	10	10	10	10
Dr	Assen	38	38	40	39	10	8	13	14	14	15	15
Dr	Emmen	30	30	32	31	6	5	19	20	20	21	22
Dr	Hoogeveen	58	58	60	59	16	9	16	16	17	17	18
Dr	Meppel	68	68	69	69	22	13	13	14	16	15	16
o v	Zwolle	79	79	80	79	26	19	30	31	33	33	35
o v	Ommen	71	71	72	72	26	7	13	14	16	15	17
o v	Almelo	54	55	56	56	21	19	23	23	24	24	26
o v	Hengelo	66	67	68	68	30	22	31	31	32	32	34
o v	Enschede	47	48	48	49	15	20	33	33	34	35	36
o v	Deventer	95	95	96	96	39	27	33	34	37	36	39
Ge	Arnhem	92	94	92	93	43	33	47	47	51	49	53
Ge	Ede	88	90	88	89	47	21	42	44	47	46	49
Ge	Harderwijk	84	84	84	84	42	20	28	29	32	30	33
Ge	Apeldoorn	99	100	100	100	40	23	47	48	50	50	53
Ge	Zutphen	89	90	90	90	38	23	26	26	29	27	30
Ge	Winterswijk	30	31	31	32	14	4	10	10	13	11	13
Ge	Doetinchem	53	54	54	54	23	12	18	19	22	20	23
Ge	Nijmegen	76	78	76	77	34	44	44	44	48	46	51
Ge	Tiel	70	71	69	69	42	20	27	28	31	28	32
Ut	Utrecht	98	99	92	92	61	69	70	70	72	70	73
Ut	Amersfoort	97	97	93	93	58	36	49	51	53	52	55
NH	Amsterdam	100	100	82	81	52	92	100	100	100	100	100
NH	Haarlem	82	82	64	63	77	71	70	70	70	64	65
NH	IJmuiden/Velsen	64	63	50	49	61	33	45	45	46	40	41
NH	Zaandam	83	83	67	66	100	58	80	80	80	74	74
NH	Alkmaar	47	47	39	38	38	33	36	38	38	35	35
NH	Den Helder	11	10	10	9	11	14	17	17	17	18	17
NH	Hoorn	49	49	41	40	38	26	29	32	32	29	30
NH	Hilversum	91	92	91	90	65	42	53	53	55	56	58
ZH	Den Haag	50	50	42	42	41	100	78	77	78	79	79
ZH	Leiden	56	56	46	45	64	56	55	56	57	55	56
ZH	Gouda	69	69	60	60	71	47	51	52	54	51	53
ZH	Gorinchem	80	81	75	75	60	30	37	38	41	37	41
ZH	Dordrecht	67	68	64	64	61	39	54	54	57	56	59
ZH	Rotterdam	70	70	65	64	41	77	87	86	88	90	91
Ze	Middelburg	39	39	39	39	10	9	11	11	14	11	14
Ze	Vlissingen	38	37	38	37	8	10	12	11	13	12	13
Ze	Terneuzen	0	0	0	0	2	0	5	5	7	5	7
Ze	Goes	28	28	27	27	11	4	9	10	12	10	12
Ze	Zierikzee	24	25	24	24	17	4	5	5	8	5	7
NB	Den Bosch	80	82	81	82	45	33	42	42	47	44	49
NB	oss	78	80	80	81	42	26	32	33	37	35	40
NB	Helmond	69	72	70	73	40	24	33	34	41	36	43
NB	Eindhoven	68	71	69	72	29	41	47	47	53	50	56

Appendix B: continued

NB	Tilburg	60	63	61	62	35	36	46	46	51	48	54
NB	Breda	62	64	57	59	41	33	44	45	50	46	52
NB	Roosendaal	54	55	50	51	31	19	27	28	32	28	33
NB	Bergen op Zoom	43	46	40	42	25	16	21	22	28	22	29
Li	Maastricht	6	14	8	15	4	20	22	22	33	24	36
Li	Heerlen	8	16	10	18	6	18	19	20	31	21	33
Li	Sittard/Geleen	20	25	22	26	11	16	20	20	28	22	30
Li	Roermond	32	37	34	38	15	12	14	14	21	15	23
Li	Weert	39	42	40	43	22	9	18	18	25	19	26
Li	Venray	46	51	48	52	23	8	17	18	25	19	27
Li	Venlo	37	43	38	45	15	15	19	20	30	21	33
Fl	Almere	76	76	70	70	58	22	37	45	46	43	45
Fl	Lelystad	63	63	61	60	31	12	27	29	30	29	30
Fl	Emmeloord	58	58	59	59	22	6	18	18	20	19	20

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Fl = Flevoland

1 = centrality via road (1983 = 1989)
2 = conform 1, foreign cities added (1989)
3 = conform 1, congestion added (1989)
4 = conform 1, foreign cities and congestion added (1989)
5 = accessibility via road, without internal interaction potential (1983)
6 = accessibility via road, internal interaction potential measured by surface municipalities (1983)
7 = accessibility via road, internal interaction potential measured by population density (1983)
8 = conform 7 (1989)
9 = conform 8, foreign cities added
10 = conform 8, congestion added
11 = conform 8, foreign cities and congestion added